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1 between them. These devices are designed to expand without reversing or contracting once they are installed.

US Patent 5,081,811,^{52-223,13} granted to Kensuke Sasaki on January 21, 1992 (Sasaki '811) takes a different approach. Sasaki '811 uses a special
 5 one-way sliding nut that is attached to the wood member upon which it bears. As the building shrinks or settles, the Sasaki nut travels with the building down on the rod by means of its one-way sliding feature.

Another approach is taught by US Patent 4,812,096.⁴¹¹⁻²³¹ This patent was granted to Peter O. Peterson on March 14, 1989. In this method, the
 10 tension rods are pulled into connecting brackets as the building shrinks and settles, such that the over-all length of the tie-down system is reduced.

The present invention represents an improvement over the prior art methods. The present invention provides a novel expansion device that is fully adjustable, has protective members for shielding the working
 15 mechanisms of the device from the elements and dirt and grime, provides a rigid force transmitting mechanism, and has built in redundancy in the expansion mechanism so that the device is less likely to fail.

Brief Summary of the Invention

The present invention consists of a connection, having an anchored,
 20 elongated tension member, a fastening member attached to the elongated tension member, a resisting member that receives the elongated tension member and an expansion device that receives the elongated tension member there through and is compressively loaded between the fastening member and the resisting member by operation of the fastening member on the
 25 elongated tension member.

The expansion device consists of a surrounding sleeve having two ends, and a central aperture through which the elongated tension member is inserted. A portion of the central aperture is formed as a substantially cylindrical inner surface and at least a portion of the cylindrical inner surface
 30 is formed with a thread. First and second bearing members are received in the central aperture of the surrounding sleeve and operatively connected to the surrounding sleeve. The first and second bearing members also have apertures through which the elongated tension member is inserted. At least one of the bearing members has a cylindrical outer surface formed with a
 35 thread that mates with the thread of the cylindrical inner surface of the surrounding sleeve and is connected to the surrounding sleeve only by the

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- 1 mating attachment of the thread on the cylindrical outer surface with the
thread of the surrounding sleeve. This bearing member can rotate in relation
to the surrounding sleeve. The first and second bearing members are formed
with outer axial ends that protrude out of the surrounding sleeve with the
5 outer axial end of the first bearing member contacting the fastening member,
and the outer axial end of the second bearing member contacting the
resisting member. A torsion spring connects the first and second bearing
members and is located within the surrounding sleeve. The torsion spring
biases the first and second members in opposite rotational directions such
10 that at least one of the bearing members is forced to rotate along said thread
of said surrounding sleeve away from the other bearing member and out of
the surrounding sleeve.

It is an object of the present invention to provide an expansion device
for a tie down connection system that operates to assure continued tightness
15 and rigidity in a connection system.

It is a further object of the present invention to provide a expansion
device that is fully adjustable. In the present invention the rotating bearing
member or members ride along a helical thread. There are no steps in the
thread, thus any separation of the two working members making up the
20 connection, no matter how small, that is within the expansion range of the
device, can be accommodated.

It is a further object to provide a expansion device that resists
contracting or shrinking under compression loads such as those exerted on a
tie-down system during a large seismic event. Mated threaded connections
25 are highly resistant to movement unless some rotational force is introduced,
and the torsion spring resists rotational forces that would contract the
device.

It is a further object of the invention to provide an expansion device
that is relatively maintenance free and whose working parts are relatively
30 protected from water, debris and dust. In the preferred embodiment of the
present invention, the torsion spring is almost completely sealed from the
outside by the combination of the surrounding sleeve, the first and second
cylindrical bearing members, the sizing sleeve, and the o-rings.

It is a further object of the present invention to provide an expansion
35 member that is strong and can adequately transmit forces from one working
member at one end of the device to another working member at the other

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1 end of the device. The preferred embodiment uses two threaded cylindrical bearing members that mate with the thread of the surrounding sleeve. The threaded connection between the components creates a strong mechanical connection that is resistant to shaking and vibration.

5 It is a further object of the present invention to provide a expansion device that has built-in redundancy in its expansion mechanism so that the device is less likely to fail. In the preferred embodiment of the present invention, the first and second cylindrical members are both driven by the same torsion spring. Should one of the cylindrical bearing members become
10 jammed and unable to rotate on the threads of the surrounding sleeve, the other cylindrical member will continue to rotate in response to the forces generated by the spring.

It is a further object of the present invention to provide a compact expansion device that can be used with tie down brackets that can be placed
15 within 2x4-framed walls. This benefit is accomplished in part by the use of the threaded connection between the cylindrical bearing members and the sizing sleeve. The threads of the cylindrical bearing member create an adequate bearing and force transmission surface while providing the device with a small footprint.

20 It is a further object of the invention to provide a device that is easily installed and incorporated into present building practices. The present invention is easily slipped over a rod or bolt before a nut and washer are tightened down.

Brief description of the drawings

25 Figure 1 is an exploded view of an expansion device of the present invention. Figure 1 also shows a nut, a washer and a locking clip.

Figure 2A is a cross-sectional side view of the surrounding sleeve of the expansion device of the present invention. The torsion spring is shown inserted into the surrounding sleeve. The torsion spring is shown at its rest
30 position. For clarity, the threads on the surrounding sleeve are shown only in cross-section. This drawing convention is used in all of the side views of the device.

Figure 2B is a cross-sectional side view of the surrounding sleeve. The torsion spring is shown inserted into the surrounding sleeve over a sizing
35 sleeve.

1 Figure 2C is a cross-sectional side view of the surrounding sleeve.
The torsion spring is shown inserted into the surrounding sleeve over a
sizing sleeve. First and second cylindrical bearing members are shown in
cross-section. They are disposed above and below the surrounding sleeve
5 and are ready to be inserted onto the tangs of the torsion spring.

Figure 2D is a cross-sectional side view of the surrounding sleeve.
The torsion spring is shown inserted into the surrounding sleeve over a sizing
sleeve. The sizing sleeve is shown in cross-section. The first and second
cylindrical bearing members are shown in cross-section. They are shown
10 threaded into the surrounding sleeve in the cocked and ready position. The
means by which the first and second bearing members are held in the ready
position are not shown.

Figure 3A is a view similar to figure 2D, except that the locking clip is
shown in cross-section ready to be inserted onto the expansion device to
15 hold the first and second cylindrical bearing members in the ready position.

Figure 3B is a view similar to figures 2D and 3A, except that the
locking clip has been inserted over the expansion device to hold it in its ready
position. The flanges of the locking clip engage the shoulders of the first and
second cylindrical bearing members. The shoulders are aligned with the end
20 surfaces of the surrounding sleeve.

Figure 4A shows a connection made according to the present
invention. The expansion device is shown in cross section. The locking clip
is shown inserted onto the expansion device. The expansion device receives
an anchor bolt embedded in a concrete foundation. A nut, shown in cross
25 section, is threaded onto the anchor bolt. The nut bears on a washer which
bears upon the expansion device. The expansion device bears upon another
washer that receives the anchor bolt there through. The washer bears upon
the crossbars of a holdown 12. The crossbars are shown in cross-section.
The holdown 12 is shown attached to a vertically disposed structural
30 member by means of threaded fasteners driven through the back member of
the holdown 12 and into the structural member.

Figure 4B shows a connection made according to the present
invention. It is similar to figure 4A except that the locking clip has been
removed and the device is shown in its expanded position.

35 Figure 5A is perspective view of a connection made according to the
present invention. The locking clip is shown attached to the device.

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1 Figure 5B is perspective view of a connection made according to the present invention. The locking clip is shown, having been removed from the device.

5 Figure 6A is an exploded perspective view of the parts of the expansion device inserted over a tension member. The means by which the expansion device retains its position on the tension member are not shown.

10 Figure 6B is a perspective view of the expansion device as it would appear in its ready position. The means by which the expansion device is held in its ready position are not shown. The means by which the expansion device retains its position on the tension member are not shown. A nut and washer are shown threaded onto the tension member above the expansion device.

15 Figure 6C is a perspective view of the expansion device as it would appear in its ready position with the locking clip attached. The means by which the expansion device retains its position on the tension member are not shown.

20 Figure 6D is a view similar to figure 6A. It is an exploded perspective view of the parts of the expansion device inserted over a tension member. The means by which the expansion device retains its position on the tension member are not shown. This view differs from figure 6A in that the threads of the cylindrical members and the surrounding sleeve are oppositely threaded.

25 Figure 7 is a perspective view of a shearwall attached to a foundation, showing the typical environment in which the connection of the present invention is used.

 Figure 8 is an exploded perspective view of the parts of an alternate expansion device inserted over a tension member. The means by which the expansion device retains its position on the tension member are not shown.

30 Figure 9 is a cross-sectional side view of the surrounding sleeve of the alternate embodiment. The torsion spring is shown inserted into the surrounding sleeve over a sizing sleeve. The sizing sleeve is shown in cross-section. The first and second cylindrical bearing members are shown in cross-section. They are shown threaded into the surrounding sleeve in the cocked and ready position. The locking clip has been inserted over the expansion device to hold it in its ready position. The flanges of the locking clip engage the shoulders of the first and second cylindrical bearing

1 members. The shoulders are aligned with the end surfaces of the surrounding sleeve.

Figure 10 is a view of the alternate embodiment similar to figure 4A.

Description of the preferred embodiment

5 As shown in figures 4A, 4B and 5A, the present invention relates to a connection between an elongated tension member 1, a fastening member 2 attached to the elongated tension member 1, a resisting member 3 that receives the elongated tension member 1 and an expansion device 4 disposed between the fastening member 2 and the elongated tension member 1.

The elongated tension member 1 has first and second ends 5 and 6 with the second end 6 being anchored. For example, said elongated tension member 1 could be a threaded anchor bolt 7 with its second or lower end 6 embedded in the concrete foundation 8 of a building. Preferred anchor bolts 15 7 for embedment in a concrete foundation 8 to be used in the present connection are SSTB anchor bolts.

The fastening member 2 is attached to the first end 5 of the elongated tension member 1. The fastening member 2 need not be attached at any particular location on the elongated tension member 1, reference is made to 20 the first and second ends 5 and 6 of the elongated tension member 1 merely to designate that the anchoring of the elongated tension member 1 and the attachment of the fastening member 2 to the elongated tension member 1 do not occur at the same place on the tension member 1. The preferred fastening member 2 is a threaded nut 9 and washer 10 combination, with 25 the thread of the nut 9 mating with the thread 11 of the elongated tension member 1.

A resisting member 3 also receives the elongated tension member 1. The elongated tension member 1 may pass through an opening or notch in the resisting member 3 or may be enveloped by the resisting member 3 in 30 some other manner. The resisting member 3 is disposed below the fastening member 2 on the tension member 1. The fact that the fastening member 2 is described as being located below the fastening member 2 does not require that the elongated tension member 1 be vertically oriented. The resisting member 3 may be a plate or bracket, or preferably part of a 35 holdown 12 that is used in a tie-down system for a building. As is shown in

1 figures **4A**, **4B** and **5A** the resisting member **3** is part of a holdown bracket
12 attached to vertical member or post **13** in a building.

The expansion device **4** of the present invention also receives the
elongated tension member **1** and is disposed between the fastening member
5 **2** and the resisting member **3**, contacting both. The expansion device **4** is
compressively loaded between said fastening member **2** and the resisting
member **3** by operation of the fastening member **2** on the elongated tension
member **1**. In the preferred embodiment, as is shown in figures **4A**, **4B** and
5A, a nut **9** and washer **10** are tightened onto an anchor bolt **7** embedded in
10 a foundation **8**. The nut **9** and washer **10** compress the expansion device **4**
against the resisting member **3** which in this case is a washer **14** supported
by the crossbars **15** of a holdown **12** attached to a post **13** in the building.
The post **13** resists this compression load by bearing on the foundation **8** or,
as is shown in figure **5A**, a mudsill **16** resting on the foundation **8**.

15 In its most basic form, the expansion device **4** has a surrounding
sleeve **17**, first and second bearing members **18** and **19** connected to the
surrounding sleeve **17** and a torsion spring **20** that can rotate at least one of
the bearing members **18** or **19** in the surrounding sleeve **17**, which causes
said rotatable bearing member **18** or **19** to travel further out of the
20 surrounding sleeve **17**, expanding the length of the device **4**.

The surrounding sleeve **17** of the expansion device **4** has two ends **21**
and **22**, and a central aperture **23** through which the elongated tension
member **1** is inserted. A portion of the central aperture **23** is formed as a
substantially cylindrical inner surface **24** and at least a portion of the
25 cylindrical inner surface **24** is formed with a thread **25**. Preferably,
substantially all of the central aperture **23** is formed as a cylindrical inner
surface **24** having a thread **25** along substantially its entire length.

First and second bearing members **18** and **19** are received in the
central aperture **23** of the surrounding sleeve **17** and operatively connected
30 to the surrounding sleeve **17**. The first and second bearing members **18** and
19 also have apertures **26** and **27** through which the elongated tension
member **1** is inserted. For operation of the invention, at least one of the
bearing members **18** or **19** has a cylindrical outer surface **28** or **29** formed
with a thread **30** or **31** that mates with the thread **25** of the cylindrical inner
35 surface **24** of the surrounding sleeve **17** and is connected to the surrounding
sleeve **17** only by the mating attachment of the thread **30** or **31** on the

1 cylindrical outer surface 28 or 29 with the thread 25 of the surrounding sleeve 17. This allows this bearing member 18 or 19 to rotate in relation to the surrounding sleeve 17.

5 The first and second bearing members 18 and 19 are also formed with outer axial ends **32** and **33** that protrude out of the surrounding sleeve 17. The outer axial end 32 of the first bearing member 18 contacts the fastening member 2, and the outer axial end 33 of the second bearing member 19 contacts the resisting member 3 .

10 A torsion spring 20 connects the first and second bearing members 18 and 19. The torsion spring 20 biases the first and second bearing members 18 and 19 in opposite rotational directions such that at least one of the bearing members 18 or 19 is forced to rotate along the thread 25 of the surrounding sleeve 17 away from the other bearing member 18 or 19 and out of the surrounding sleeve 17, if the rotational force generated by the torsion spring 20 is greater than the compression forces on the expansion device 4. The torsion spring 20 is disposed within the surrounding sleeve 17.

As is shown in figures **1** and **2D**, in the preferred embodiment, the expansion device 4 has first and second bearing members 18 and 19. Preferably, the first and second bearing members 18 and 19 are substantially identical and generally cylindrical members. In the preferred embodiment, each cylindrical bearing member 18 or 19 has a central aperture 26 or 27 there through. Preferably each cylindrical bearing member 18 or 19 spins on the central axis **34** of the expansion device 4. The cylindrical bearing members 18 and 19 are assembled in opposed axial alignment within a surrounding sleeve 17, such that the central apertures 26 and 27 of the cylindrical bearing members 18 and 19 are in alignment.

As is shown in figures **2C** and **2D**, in relation to the surrounding sleeve 17, the cylindrical bearing members 18 and 19 have outer axial ends 32 and 33 and inner axial ends **35** and **36**. The inner axial ends 35 and 36 of the cylindrical bearing members 18 and 19 face each other within the surrounding sleeve 17. The outer axial ends 32 and 33 have substantially planar surfaces **37** and **38** which are, preferably, orthogonal to the central or longitudinal axis 34 of the expansion device 4

35 As is shown in figures **1**, **2C** and **2D**, in the preferred embodiment, the first and second cylindrical bearing members 18 and 19 are each formed with

1 a thread 30 or 31 on their outer surface 28 or 29. These threads 30 and 31
mate with an inner thread 25 on the surrounding sleeve 17, such that the
cylindrical bearing members 18 and 19 can travel within the surrounding
sleeve 17 by being rotated. In the preferred embodiment, the entire inner
5 surface 24 of the surrounding sleeve 17 is formed with a single thread 25 of
uniform pitch. Also, in the preferred embodiment, the only connection
between the surrounding sleeve 17 and the first and second cylindrical
bearing members 18 and 19 is by means of their respective threaded
surfaces 24, 28 and 29. Thus, each cylindrical bearing member 18 or 19
10 can travel freely along the inner thread 25 of the surrounding sleeve 17.

In the preferred embodiment, the expansion or lengthening of the
device 4 along its central axis 34 is accomplished by the movement of both
the first and second cylindrical bearing members 18 and 19 in the
surrounding sleeve 17. When the expansion device 4 is first installed, the
15 first and second cylindrical bearing members 18 and 19 are threaded into the
surrounding sleeve 17 from both ends 21 and 22 such that their inner axial
surfaces 35 and 36 lie relatively close to each other and their outer axial
surfaces 32 and 33 protrude only slightly from the ends of the surrounding
sleeve 17. See figures **2D** and **3A**. By rotating the cylindrical bearing
20 members 18 and 19 in opposite directions, they are turned either farther into
the surrounding sleeve 17 and closer to each other or out of the surrounding
sleeve 17 and away from each other. Operation of the device 4 is
accomplished by turning the first and second cylindrical members 18 and 19
in a manner that causes them to move away from each other such that their
25 outer axial surfaces 32 and 33 protrude farther out of the surrounding sleeve
17, effectively lengthening or expanding the device 4. See figure **4B**.

The pitch of the thread 25 of the surrounding sleeve 17 and the
threads 30 and 31 of the first and second cylindrical members 18 and 19 is
preferably optimized such that any rotation of the cylindrical bearing
30 members 18 and 19 results in an appreciable enlargement of the space taken
up by the device 4, while at the same time maintaining the ability of the
expansion device 4 to resist contracting under design loads.

As is shown in figures **1**, **2A**, **2B** and **2C**, a torsion spring 20 is also
received in the surrounding sleeve 17. The torsion spring 20 connects the
35 two cylindrical bearing members 18 and 19. See figures **2C** and **2D**. The
torsion spring 20 is formed with first and second ends **39** and **40**. Each end

- 1 39 or 40 of the torsion spring 20 is connected to a cylindrical bearing member 18 or 19. See figures 2D and figure 9. Preferably, both ends 39 and 40 of the torsion spring 20 are formed with tangs 41 and 42, and each tang either 41 or 42 is received within a bore 43 or 44 in each of the
- 5 cylindrical bearing members 18 or 19. The torsion spring 20, when wound, serves as a resilient torsion member, rotating the cylindrical bearing members 18 and 19 in opposite directions and causing them to travel away from each other on the thread 25 of the surrounding sleeve 17.

As is shown in figure 1, in the preferred embodiment, each cylindrical

10 bearing member 18 or 19 is formed with an annular shoulder 45 or 46 near its outer axial end 32 or 33. These shoulders 45 and 46 are designed to bear upon the flanges 47 and 48 of a locking clip 49. See figure 3B.

The preferred locking clip 49 consists of a central body 50 from which two flanges 47 and 48 are bent. See figures 3A, 3B, 5A and 5B. To

15 conform to the preferred shape of the expansion device 4, the flanges 47 and 48 lie parallel to each other. The flanges 47 and 48 are each provided with a notch 51 and 52. Preferably, each notch 51 or 52 has an arced inner shape that corresponds in curvature to the to the outer diameter of the first or second cylindrical bearing members 18 or 19 between their outer axial

20 ends 32 or 33 and their annular shoulders 45 or 46.

The locking clip 49 holds the expansion device 4 in a pre-installation, cocked position. The locking clip 49 is releasably attached to the expansion device 4. When engaged with the expansion device 4, the locking clip 49 holds the first and second bearing members 18 and 19 so as to prevent them

25 from rotating under the influence of the torsion spring 20 and causing the device 4 to expand. This facilitates installation of the device 4, and ensures that the maximum expansion capabilities of the device 4 are available.

The locking clip 49 is preferably made from sheet metal. Preferably, strengthening gussets 53 are provided at the bends between the flanges 47

30 and 48 and the central body 50 of the locking clip 49. See figures 1 and 3A.

As is shown in figures 1 and 2B, in the preferred embodiment, a sizing sleeve 54 is used with the expansion device 4. The sizing sleeve 54 is a cylinder, having a central bore along its longitudinal axis. The sizing sleeve 54 is inserted into the expansion device 4 with its longitudinal axis in

35 alignment with the longitudinal axis 34 of the expansion device 4. The sizing sleeve 54 is received within the surrounding sleeve 17 with the torsion

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1 spring 20 between the sizing sleeve 54 and the surrounding sleeve 17. The
sizing sleeve 54 is also preferably received in the central apertures 26 and 27
of the first and second cylindrical bearing members 18 and 19. Different
sized sizing sleeves 54 are designed to be used with different sized tension
5 members 1 or rods. All the different sized sizing sleeves 54 have the same
outer diameter, but the diameter of the central bore varies to fit various sized
rods 1 or bolts received within the sizing sleeve 54. It is desirable to create
a close fit between the sizing sleeve 54 and the bolt 1 or rod to create a
more rigid system.

10 As is shown in figure 1, the preferred embodiment the expansion
device 4 is also provided with seals or O-ring 55 at both ends 21 and 22 of
the surrounding sleeve 17 to protect the inner thread 25 of the surrounding
sleeve 17.

The surrounding sleeve 17, in combination with the cylindrical bearing
15 members 18 and 19, the sizing sleeve 54, and O-rings 55, serves as a
protective housing for the torsion spring 20 of the expansion device 4.
During construction of a building containing the expansion device 4, the
device could be exposed to rain, dust and knocks.

The expansion device 4 is shown at its maximum useful expansion in
20 figure 4B. The expansion device 4 provides infinite adjustment within its
range of expansion. The inventors have found that configuring the device to
expand by 1" is an appropriate amount for most construction applications.

Since both cylindrical bearing members 18 and 19 rotate on a threaded
member separate from themselves — the surrounding sleeve 17 — each
25 contributes equally to the expansion of the device 4. Further, if rotation of
one of them is prevented for any reason, the other is still available to perform
the work of both.

As is shown in figures 5B and 6B, the thread of the surrounding sleeve
17 is preferably coined so as to serve as a stop for the cylindrical bearing
30 members 18 and 19. This coining 56 serves to stop the cylindrical bearing
members 18 and 19 from rotating all the way out of the surrounding sleeve
17.

Figure 7 illustrates a typical tie down installation for the wooden shear
wall 57 of a building. The shear wall rests on a concrete foundation 8. An
35 anchor bolt 7 is shown protruding from the top surface of the foundation 8.
The anchor bolt 7 extends upwardly through the mudsill 13 of the wall 57.

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1 A holdown 12 is shown connected to the end chord or vertical member 13 of the shear wall 57. The expansion device 4 of the present application need not be used in vertical applications. The device could be used horizontally in continuity ties in roofs and other similar applications.

5 Figure 6D shows the preferred direction of the thread 25 of the surrounding sleeve 17 and cylindrical bearing members 18 and 19 in relation to the thread 11 of the tension rod 1 of the preferred embodiment. It is preferable that the cylindrical bearing members 18 and 19 are threaded and driven by the torsion spring 20 in such a manner that if any of their rotational
10 motion is translated to the nut 9, the nut 9 will want to rotate in a direction that would tighten it on the tension rod 1 against the expansion device 4, rather than turning the nut 9 away from the expansion device 4. Preferably, if a threaded tension member 1 is used in connection with a threaded nut 9 as the fastening member 2, the surrounding sleeve 17 is oppositely threaded
15 with respect to the tension member 1.

Figures 8, 9 and 10 show a modified expansion device 4. The expansion device 4 of figures 8, 9 and 10 is a smaller version of the device 4 shown in the earlier figures. However, the expansion device 4 still allows for a similar change in the length of the device 4 along the axial direction. This
20 is made possible by forming annular recesses 58 and 59 in the cylindrical bearing members 18 and 19 that receive the torsion spring 20. Thus, a similarly sized torsion spring 20 can be fitted within a smaller surrounding sleeve 17. The inventor has found that a smaller device is preferable. For example, the tension rod 1 received by the expansion device 4 can be
25 shorter.

The expansion device 4 is installed on a rod 1 or bolt in the following manner. A worker slips the expansion device 4 on the rod 1 or bolt. She then attaches a nut 9 and washer 10 or some other similar fastener to the rod 1 or bolt, such that a designated compression force is exerted on the
30 expansion device 4 and there through onto a bracket 3 or plate. She then pulls the locking clip 49 away from the device 4 which allows the cylindrical bearing members 18 and 19 to move under the biasing force of the torsion spring 20 should the nut 9 and the bracket 3 or plate somehow separate.

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